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THE SCIENTIFIC CAPABILITIES OF ELMER

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RESUMEN

Elmer es un instrumento óptico multi-propósito para el GTC que ha sido diseñado y gestionado dentro de la Oficina de Proyecto. En esta contribución se presentan tanto la descripción general del proyecto instrumental (alcance, organización, calendario y presupuesto global) como un resumen de las prestaciones científicas del instrumento para los diferentes modos de observación.

ABSTRACT

Elmer is a visible imager–spectrograph currently scheduled to be in operation at the GTC on Day One. The instrument will allow imaging over a 4.2 arcminute field of view, and spectroscopy with resolutions from about 100 to over 2000, as well as fast photometry options.

Key Words: **INSTRUMENTATION : OPTICAL**

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1. INTRODUCTION

Elmer is a general-purpose instrument which was requested by the GTC Science Advisory Committee to ensure a science capability at Day One, so the design has been kept under the control of the GTC Project Office. A more detailed description of the instrument is given in M. García Vargas et al. (this volume, p. 326) and a section through the instrument is presented in Figure 1.

The principal requirement for Elmer is that it be of interest to the general community so as to provide a rapid scientific return from the GTC. A minimum baseline of imaging and low resolution spectroscopy between 370 and 1000 nm was adopted; other features were added even though it was clear that they would add significant complications to the instrument.

The detector is a 2k $\times$ 4k Marconi CCD44-82, with a 15 μm pixel size. Elmer's field of view (FOV) does not fill the detector, but this allows the frame transfer and charge shuffling capabilities of the detector to be used, resulting in very efficient operation. For exposures longer than about 10 s the dead-time between images will be reduced to under a second.

2. TOP LEVEL CAPABILITIES

The top level capabilities for Elmer are:

- Spectral range: 365 to 1000nm
- Field of view: 4.2 arc min diameter
- Plate scale: 0.195" per pixel
- Image quality: EED80 $<$ 2 pixel for imaging; EED80 $<$ 3 pixel spectroscopy
- Filters: 14 positions + open
- Spectroscopy: resolutions from 100 to 2500 (8 grisms and 2 prisms)
- Exposure times: $>$ 10 ms

2.1. *Imaging capabilities*

Elmer will offer a wide range of imaging options ranging from full FOV to fast photometry options using a $12.5'' \times 3'$ aperture on the sky. The exposures will normally be controlled using a shutter that will give effective exposure times down to about 0.01 s. For the fast photometry options, the shutter will not be used and the exposures will be controlled by the length of time the charge is stationary on the detector. In this mode, it will be possible to take 1 s integrations continuously in the $12.5'' \times 3'$ aperture with a dead-time of only 0.02 s between images. Higher frequencies will be possible for periods of a few seconds.

Fourteen filters can be mounted at one time and the initial filter set will contain:

- The Sloan Digital Sky Survey broad band filter set: g', r', i', and z'
- Narrow band filters: S II wide (672.6 nm), S II narrow (671.9 nm), Hα wide (656.8 nm), Hα narrow (656.7 nm), O I (630.5 nm), O III (498.5 nm), Hβ (486.3 nm), and O II (372.8 nm)

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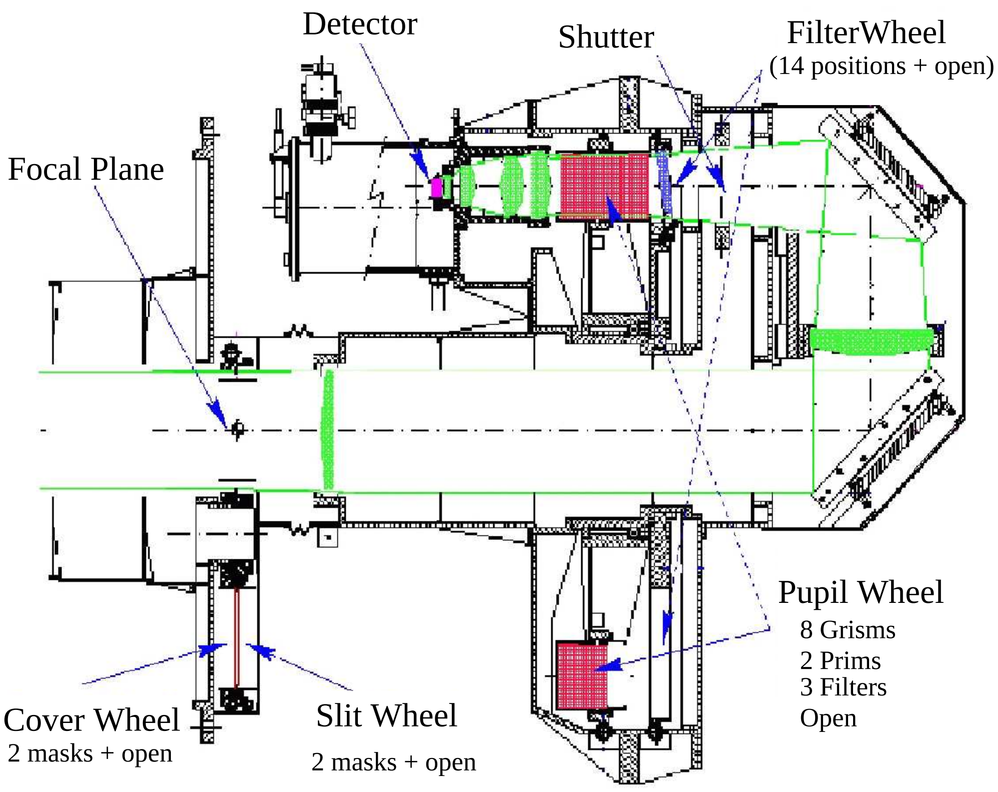

Fig. 1. A section through Elmer, indicating the main components.

- Neutral density filters

The predicted 5 sigma 1 hour limiting magnitudes in 1 arcsecond seeing are listed in the following table.

TABLE 1

LIMITING MAGNITUDE

Filter	Limiting magnitude (5 sigma 1 hr)
g'	27.5
r'	26.8
i'	26.0
O III	26.1
Hα	25.3

2.2. *Spectroscopic capabilities*

Prisms and grisms give Elmer a spectrographic capability with resolutions between 100 and 2500 in the 0.6″ slit (see Figure 2).

The spectroscopic modes offered are:

- Long slit: length 3′, widths 0.6″, 1.2″, 2″, and 5″

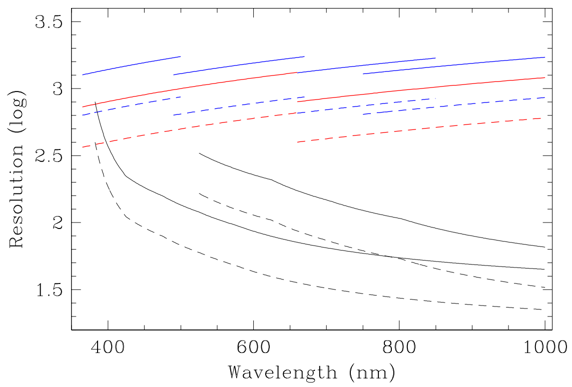

Fig. 2. Spectral resolutions for Elmer for the 0.6″ (solid line) and 1.2″ (dashed line) slits. The lower resolutions are for the prisms.

- Short slit: length 20” widths 0.6”, 1.2”, 2” and 5” (for fast spectroscopy),

- Charge shuffling: A special slit with alternatively 18” open and 22” closed will be available.

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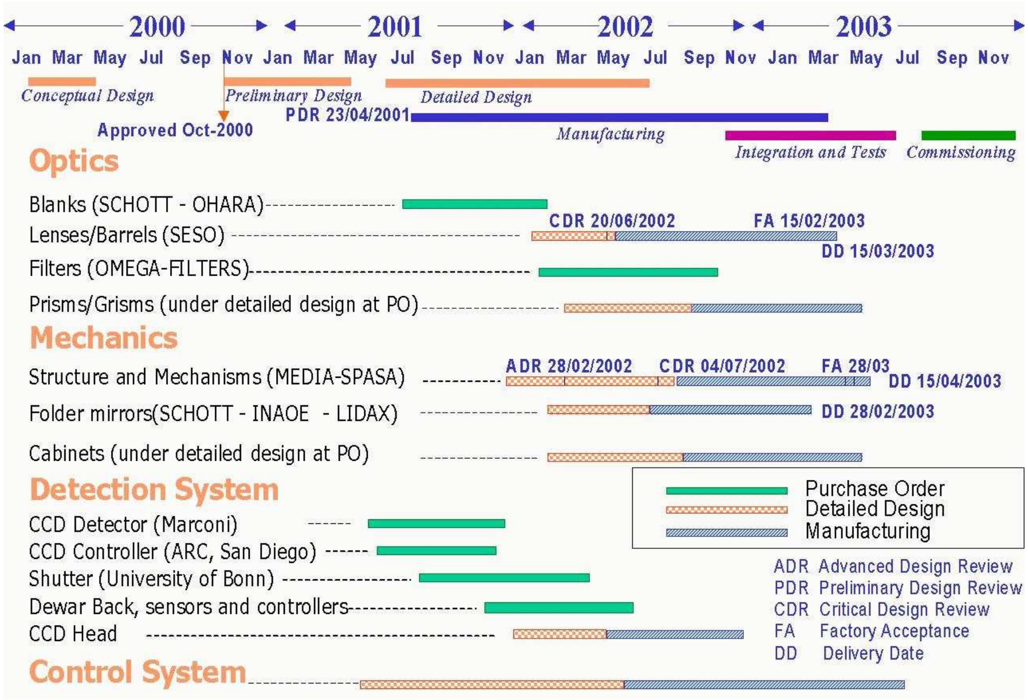

Fig. 3. The overall schedule for Elmer (top) is shown along with those for the main elements of each subsystem.

When this is used with charge shuffling it will allow a better sky subtraction.

- Slitless: No slit is used, so point sources make there own slit.

- Multislit: Potentially there is a limited multi-slit capability over a 3x3 arc minute FOV. Only one or two masks can be mounted at at time.

All of the spectroscopic (except multislit) modes will be available at the same time. The time necessary to switch between modes will be under 30 seconds.

3. ELMER DATA PIPELINE

The Data Reduction Pipeline (DRP) is an essential tool to provide a rapid scientific return. Real time and off-line reduction pipelines will be fully integrated in the GTC control system. Both the reduced and raw data will be distributed to the astronomers, and the processing will be as complete as possible to ease a quick return from the GTC to the scientific community. Two datasets will be distributed to the astronomers:

- The raw data, both the calibrations and the observations.

- The scientific validated data (reduced according to a standard reduction template) including the associated error frames.

The astronomer will also be given the quality control report provided by the GTC Observatory staff. The complete Elmer DRP is being undertaken as a collaboration between the GTC Project Office (PO), which has developed the software architecture and the basic libraries and is responsible of the final integration of the DRP, and the Astrophysics Group of the Universidad Complutense de Madrid, who have implemented the specific reduction filters for Elmer. The acquisition and guiding system and the commissioning camera are following the same approach.

The filters for producing the scientific validated data include "basic reduction" plus specific reduction for each observing mode. The basic reduction corrects for the bias, zero, dark current, and flat field corrections plus the bad pixel removal and cosmic ray detection. Once the basic reduction has been performed, the data is extracted:

- For imaging this includes the geometric distortion correction and point source extraction. The instrumental constants and extinction coefficients will be included in the headers so that fluxes can be determined directly if required.

- For long slit spectroscopy, a slit and wavelength distortion map will be created along with a differential refraction distortion map. It will be possible to extract the spectra from predefined positions in the slit.

4. MANAGEMENT AND SCHEDULE

Elmer's development is being controlled directly by the GTC Project Office. The whole preliminary design and a significant part of the detailed design has been done at the PO to minimize the cost and the delays. The budget for Elmer is to be under 1.2 MEuros plus a manpower cost to the PO of 6.5 man-years. Most of the purchase orders and contracts for the different Elmer subsystems have been made (see Figure 3). Only the grisms and part of the cryostat are not currently being manufactured and these are in the detailed design stage. The schedule for Elmer is being met both by the PO and by the subcontractors, and the instrument is expected to be fully integrated in La Laguna for the commencement of laboratory testing at the end of 2003 May, well in advance of the date in which it will be required at the ORM.

5. CONCLUSIONS

Having followed a low risk design, with no complicated mechanisms, Elmer will be very sensitive and will also operate very efficiently; it will therefore provide high quality scientific data early on in the operational life of the GTC.

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